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Climate-related displacements of coastal communities in the Arctic: Engaging traditional knowledge in adaptation strategies and policies

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ABSTRACT

Climate change impacts lead to alterations in migration patterns and the displacement of exposed native communities and peoples in the Arctic region, forcing them to leave their homes and traditional ways of life as a result of rapid local ecological changes. This paper illustrates climate-related displacements and subsequent relocation as extremely complex processes, and proposes traditional knowledge as a relevant source of knowledge both at local level and policy making spheres.

The main conclusions are that the representation of indigenous peoples in international governance structures does not guarantee that traditional knowledge is entirely engaged in evidence-based policy making and that traditional knowledge is not always valued as an equal source of knowledge by some relevant scientific bodies. In this context, changing the approach towards a knowledge-systems-based framework would contribute to the development of more concrete policies and strategies for adaptation of Arctic native communities.

1. Introduction

While global consciousness of the effects of climate change is increasing within the general public, the impacts on small communities at the local level remain less well known. Among these impacts, the displacement phenomenon is one of the consequences of rapid ecological changes. This paper analyses studies of the vulnerability of traditional coastal communities under risk of displacement in the Arctic region. It aims at identifying opportunities and pathways to engage local native communities in policy-making processes, and assessing the potential of traditional knowledge to mitigate those impacts.

The Arctic region is not homogeneous; there is a large variety of cultural, historical, and economic backgrounds among the groups and local communities (Koivurova et al., 2008), and although natural and human environments in the region have their own specificity, they share a common circumstance: a potential vulnerability condition, but also a significant resilience capacity. The effects of climate change threaten biodiversity, local economies, and social and cultural systems of the region, posing serious challenges to their sustainability.

Throughout human history, migration and displacement have been recurrent phenomena and have periodically occurred around the globe due to several factors (Kelman and Næss, 2013), such as colonisation (Armstrong, 1978), conflicts (Park, 1928; Wood, 1994; Ibáñez and Vélez, 2008; Czaika and Kis-Katos, 2009), sovereignty claims (Dauvergne, 2004), and development projects (Stanley, 2004; Vandergeest et al., 2010; Penz et al., 2011), among others. Migration refers to the geographical movement of people in order to improve quality of life (Benson and O'reilly, 2009; Castles et al., 2013), while displacement has been defined in varying ways. Displacement is forced, involuntary, and highly adverse to affected peoples (Cernea, 2003), including physical, economic, and social exclusion (Cernea, 2005). Other authors consider displacement a phenomenon conceptually and morally distinct from the loss of economic or resource use rights (Agrawal and Redford, 2007); But as Mascia and Claus (2009) point out, in order to understand the full empirical and ethical dimensions of the displacement phenomenon, it is critical to consider the disempowerment of peoples and groups who lose rights and the empowered ones who gain rights. In practical terms, when severe impacts to individuals and communitites' lives are inevitable and irreversible, affected communities are forced to abandon their homes and ways of life.

According to Terminski (2012, p. 39) it is fair to distinguish the general category of *environmental migrants* from the more specific and subordinate category of environmentally displaced people. Environmental migrants are "persons making a short-lived, cyclical, or longer-

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term change of residence, of a voluntary or forced character, due to specific environmental factors". Environmentally induced displacement is applied to "persons compelled to spontaneous, short-lived, cyclical, or longer-term changes of residence due to rapid or gradually-worsening changes in environmental dynamics critical to their subsistence, which may be of either a short-term or irreversible character".

These definitions provide a general framing of the causes of climate-related migration and displacements. They seem to suggest that whilst environmental changes may lead to important impacts on local communities, forcing them to abandon their homes, displacement phenomena are also influenced by governance and social issues related to policy and decision-making processes. In the reminding of this paper, we will first examine climate related displacements in Arctic as depicted in literature, the engagement of communities potential to address those displacements, and the level of integration of traditional knowledge into scientific and policy processes; finally, based on this literature review, we offer a set of recommendations and proposals which encourage the value of this body of knowledge.

2. Climate-related displacements in the Arctic

Environmental hazards and chronic environmental degradation due to climate change are potential sources of displacement and migration (Swain, 1996; Raleigh et al., 2008), particularly in territories of high social and ecological vulnerability, such as island territories (Kelman, 2018) and remote regions, including the Arctic.

2.1. Impacts on small coastal communities

The impacts of climate change on Arctic coastal zones could have potentially both positive or negative effects (see Table 1). For instance, the reduction of sea ice thickness might facilitate access to marine resources, as well as, increase coastal erosion affecting stability of infrastructures and cultural heritage sites (Couture et al., 2002). In fact, the alteration of terrestrial and marine ecosystems may imply changes in marine resource availability, and since scientific assessment methods for data collection in fisheries science are not fully certain, there is a high level of uncertainty in, among other areas, further stock assessment actions.

Effects of climate change include socio-environmental impacts such as the increase of risks on food security due to uncertain changes in species distribution and availability; impacts on infrastructure, including schools, hospitals, various types of buildings and structures; and facilities, such as roads, railways, airports, pipelines, harbours, power stations, and power, water, and sewage lines (ACIA, 2005). Residents of many Arctic communities commonly drink untreated water directly from a variety of natural sources, including lakes, streams, and rivers in summer, and from lake ice, icebergs, snow, and multi-year sea ice in winter (Nickels et al., 2005; Martin et al., 2007; Daley et al., 2015).

These environmental changes have impacts on the social system. In other regions, displacement and loss of access to common natural resources are closely associated with social disarticulation, landlessness, loss of identity, increased morbidity and mortality, and marginalisation (Cernea and Schmidt-Soltau, 2003).

For instance, the loss of permafrost due to climate warming has already caused impacts in ecosystems and communities through collapse of roads and buildings as the ground becomes unstable (Schaefer et al., 2012). Millions of people live in the permafrost area, including in three large cities built on continuous permafrost (see Fig. 1). These cities would most likely transition to the discontinuous permafrost zone with 2 °C of warming (Chadburn et al., 2017), putting their infrastructure at risk of collapse in the coming decades as the ground becomes weaker.

When these impacts are highly intense and irreversible, relocation becomes a critical consequence and a vital decision for affected local communities. Relocation has been defined by Bronen (2010) as a process whereby livelihoods, housing, and public infrastructure are reconstructed in another location and may be the best adaptation response for communities whose current locations become uninhabitable or vulnerable to future climate-induced threats. Therefore, changes in the ecological system seriously affect the sustainability of these communities inducing displacements (Ferris, 2013), and if these impacts are not correctly mitigated, complex processes of relocating entire communities might become a reality in many Arctic coastal areas.

2.2. Relocation events: an overview of the case of Alaska native villages

According to Petz (2015), planned relocation occurred in the context of three types of situations:

I In anticipation of disasters, environmental change, and/or the effects of climate change;
II As a response to disasters, environmental change, and/or the effects of climate change; and
III As a consequence of measures related to climate change adaptation or disaster risk reduction measures.

Including islands, Alaska has 33,904 miles of shoreline; from these, approximately 6600 miles – 19.5% of the total coastline area – and many low-lying areas along the state's rivers are subject to severe flooding and erosion. Most of Alaska's native villages are located on the coast or on riverbanks. In 2003, the US Government Accountability Office (GAO) reported that flooding and erosion affects 184 out of 213, or 86.4 percent, of Alaska native villages to some extent (GAO, 2003).

Rising temperatures in recent years have led to widespread thawing of permafrost, causing village shorelines and riverbanks to slump and erode, threatening homes and infrastructure. Rising temperatures also affect the thickness, extent, and duration of sea ice that forms along the western and northern coasts. The loss of sea ice leaves shorelines more vulnerable to waves and storm surges and, coupled with the thawing permafrost along the coasts, accelerates the erosion threatening the villages. In addition, the loss of sea ice changes the habitat and accessibility of many of the marine mammals that Alaska natives depend upon for subsistence (Mittal, 2009).

The US Government Accountability Office reported that 31 communities were severely threatened by flooding and erosion, and 12 of them were identified as "at imminent risk" (GAO, 2003) and decided to relocate – in part or entirely – or to explore relocation options (Fig. 2). The villages of Kivalina, Newtok, Shaktoolik, and Shishmaref face the most imminent threat (GAO, 2003; Bronen, 2008). In these cases, survival in and of the settlements is unlikely, and residents have begun to actively seeking the opportunity to relocate (GAO, 2009).

According to Mittal (2009), limited progress has been made on relocating the 12 villages severely threatened by flooding and erosion since only one, Newtok, has made significant progress. For several of these communities, there is limited comprehensive information about climate-related threats to community habitability and the options to prevent community displacement (Ferris, 2013).

Relocation is a complex issue since it implies several impacts, different actors, and high levels of uncertainty. Forced relocation and inadequate governance mechanisms and budgets to address climate change and support adaptation strategies may cause loss of community and culture, health impacts, and economic decline (Maldonado et al., 2013). While these communities are weighing relocation options, the environmental impacts continue putting in risk their livelihoods.

Following the report made by the US Government Accountability Office (GAO, 2009), relocation efforts have not achieved the expected results due to several complications. For instance, the economic cost estimates for relocating Kivalina range from $100 million to over $400 million (GAO, 2003), and governance deficiencies are highlighted by the difficulty in reaching consensus to relocate when exploring options

Table 1
A summary of main sources of environmental changes and impacts that could lead to displacements of Arctic coastal communities.

Environmental changes	Governance areas	Potentially negative impacts	Potentially positive impacts
Invasive Species (Hellmann et al., 2008; Rahel and Olden, 2008).	Food security	Decrease of marine resources in some areas.	Increase of marine resources (productivity) available to humans; more productive fisheries in some regions.
Changes in the distribution and migration patterns of fish stocks (Tynan and DeMaster, 1997; Hollowed et al., 2013).		Providing food from other sources may be costlier.	
Increase of invasive species: new species moving into the Arctic and competing with native species (Hassol, 2004, Callaghan et al., 2004).			
Permafrost (Brown et al., 1997; Lawrence et al., 2008; Rowland et al., 2010).			
Ocean acidification (Riedel, 2014).			
Wave action and storm surges due to reduced sea-ice extent and sea-level rise. Ongoing or accelerated coastal-erosion trends are likely to lead to further relocations of coastal communities in the Arctic (Hassol, 2004; ACIA, 2005; Burkett, 2012).			
Changes in river ice conditions, run-off, flow regimes, and water levels can impede access to important fishing areas and increase travel hazards (Fox, 2002; Huntington et al., 2005; Prno et al., 2011).			
Despite increased annual precipitation, a net summer drying effect is occurring due to decreased seasonal precipitation, increased temperatures, thawing permafrost and increased evapotranspiration (Evengard et al., 2011).	Water security	Water quantity: reductions in water levels affect drinking water availability.	X
Shifting seasonal transitions, altering precipitation regimes, reducing snow and ice cover, and increasing exposure to solar radiation (Medeiros et al., 2016).		Water quality: contamination.	
Changes in precipitation chemistry such as decreasing pH can rapidly affect surface water chemistry (Peters and Meybeck, 2000).		Access to water: pressures on freshwater supply.	
Changes in air temperature (Chapman and Walsh, 1993; Thompson and Wallace, 1998; Przybylak, 2000; Polyakov et al., 2003).	Energy security	Inadequate or inefficient energy use at local levels.	Reduction in the demand for heating energy.
Land changes due to erosion, earthquakes, etc. (Parry, 2007; Mars and Houseknecht, 2007).	Land Rights	Loss of sovereignty. Land tenure and access rights. Loss of autonomy, political oppression, and bureaucratic control (Kirmayer et al., 2011)	X
Ice melting (Berkes and Jolly, 2002; Henshaw, 2009; Laidler et al., 2009; Ferris, 2013).	Mobility	Loss of traditional navigation routes.	Opening of new routes (transport, tourism, etc.)
Landuse changes derived from reductions in the extent of sea ice and permafrost, increased coastal erosion (Parry, 2007) or coastal land loss and thermokarst lake expansion and drainage (Mars and Houseknecht, 2007).	Social and Cultural	Social disarticulation, landlessness, loss of identity, increased morbidity and mortality, and marginalisation.	Cultural adaptation to make use of newly-introduced species may occur in some areas.
Sea-ice extent is very likely to be reduced and the animals they now hunt are likely to decline in numbers, making them less accessible, or they may even disappear from some regions (ACIA, 2005).		Population stress.	
		Loss of traditional knowledge. Disrupt or even destroy traditional hunting culture. Loss of cultural practices. Language loss. Cultural heritage loss. Access to traditional food species reduced.	
Changes in ambient temperatures (Parkinson and Butler, 2005).	Health	Increases in zoonotic diseases and injury rates.	The incidence of hypothermia and associated morbidity and mortality may decrease (Parkinson and Berner, 2009).
Temperature and humidity influence the distribution and density of many arthropod vectors (Parkinson and Butler, 2005).		The consequences of shifting to a more Western diet are likely to include increased incidence of diabetes, obesity, and cardiovascular diseases. Incidence of vector borne diseases.	
Risk of floods, mudflows, slides, and avalanches (ACIA, 2005).	Infra-structure security	Change in the maintenance conditions of many structures, especially for those designed without consideration of potential climate change.	X
Coastal erosion (Radosavljevic et al., 2016).		Materials deterioration.	
Ultraviolet (UV) radiation adversely affects many materials used in construction and other outdoor applications (Corell, 2013).		Problems associated with water-retaining dams include seepage, frost heave (in areas of seasonal frost), settlement, slope stability, slope protection, and construction methods.	
Permafrost degradation (Nelson et al., 2002; Chadburn et al., 2017).			

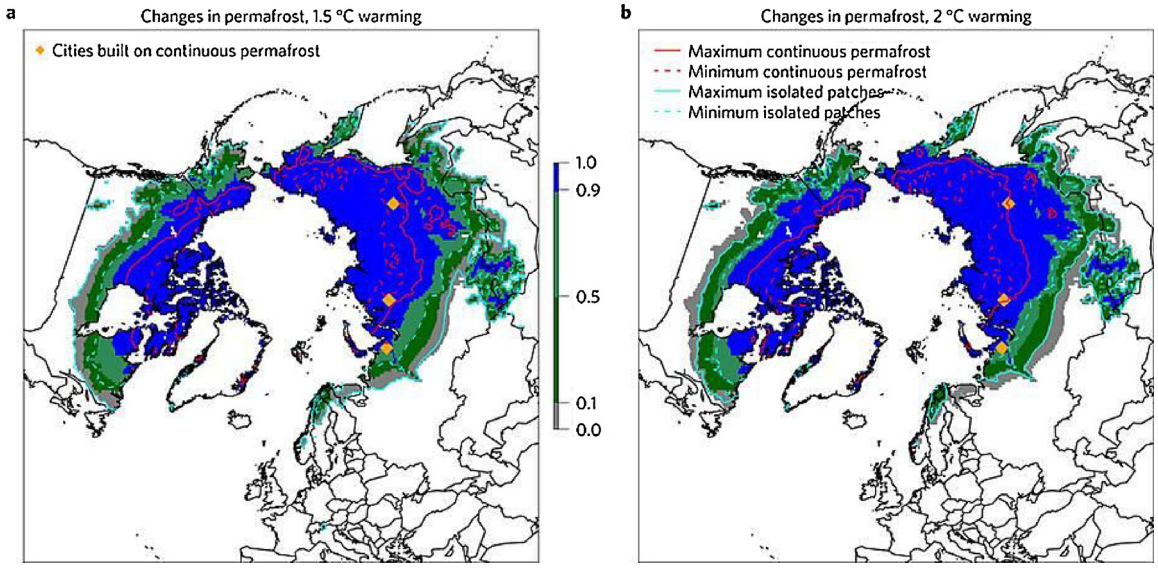

Fig. 1. Changes in spatial patterns of permafrost under future stabilisation scenarios. source: (Chadburn et al., 2017).

for Alaska native villages. None of the decisions to relocate has been unanimous in the selection and identification of alternative locations, with communities diverging on preferred solutions, or preferring to remain in place.

The lack of a lead entity has become an impediment to villages' relocation efforts (Mittal, 2009; Shearer, 2012), suggesting that governance structures and engagement actions have failed. The case of Kivalina is a clear example (Martin, 2012). The Kivalina Relocation Master Plan was released in 2006 by the U.S. Army Corps of Engineers (USACE, 2006), determining that the preferred location site for the community: Kiniktuuraq, was unsuitable and vulnerable to flooding and erosion. The ACE proposed an alternative site, which was rejected by citizens on the basis of the high economic costs and the difficulties to continue with their subsistence activities, and traditional and cultural practices. Kivalina had asked that a third party steped in to reassess the alternatives in the Relocation Master Plan; the Climate Change Sub-Cabinet's Immediate Action Workgroup proposed that a state agency be the lead in this process (GAO, 2009; Gregg, 2010). As Mittal

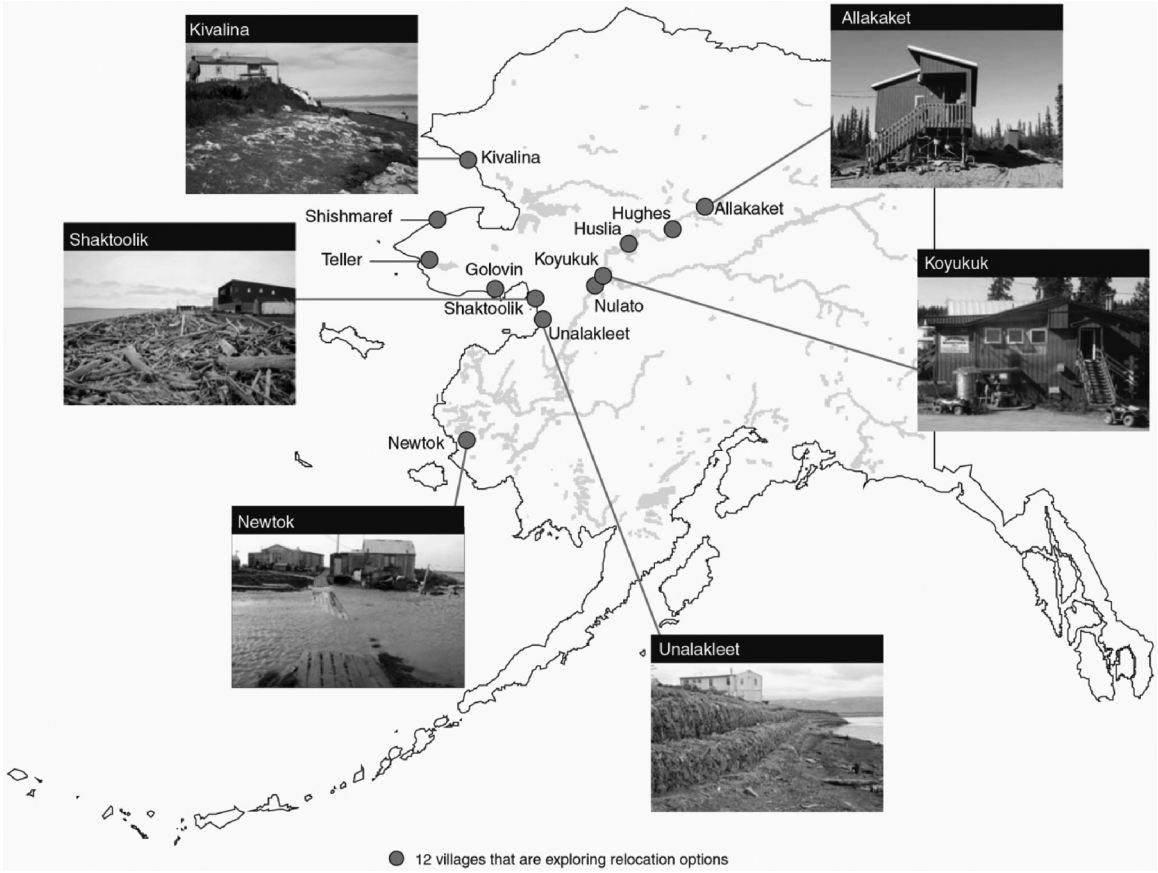

Fig. 2. Location of 12 Alaska Native Villages affected by flooding and erosion. Source: GAO, 2003.

Table 2
Overview of international actors and initiatives working with indigenous peoples and traditional knowledge.

International Institution / organisation	Some references to Traditional Knowledge
United Nations Framework Convention on Climate Change (UNFCCC) - Report of the Indigenous Peoples' Global Summit on Climate Change	To enable Indigenous peoples from all regions of the globe to exchange their knowledge and experience in adapting to the impacts of climate change, and to develop key messages and recommendations: http://www.un.org/ga/president/63/letters/globalsummitoncc.pdf
Arctic Council	Six organisations representing Arctic indigenous peoples have status as Permanent Participants: The Aleut International Association, the Arctic Athabaskan Council, the Gwich'In Council International, the Inuit Circumpolar Council, RAIPON (the Russian Association of Indigenous Peoples of the North), and the Saami Council: http://www.arctic-council.org/index.php/en/ Protection of the Arctic Marine Environment (PAME) Working Group: https://pame.is/index.php/projects/resource-exploration-and-development/mema Arctic Council archive on Indigenous engagement: https://oaarchive.arctic-council.org/browse?value=Indigenous+People&type=subject
The Arctic Circle	Science and Traditional Knowledge forums http://www.arcticcircle.org/assemblies/2016/program-news/news/indigenous-arctic-global-dialogue
UNESCO	Multimedia modules with interdisciplinary complex of indigenous knowledge related to mitigation and adaptation to environmental changes: https://iite.unesco.org/courses/climate_change/en/index.html
Inter-institutional cooperation	Arctic Monitoring and Assessment Programme (AMAP) in collaboration with the Arctic Council's Conservation of Arctic Flora and Fauna (CAFF) working group, and the International Arctic Science Committee (IASC). ACIA - Arctic Climate Impact Assessment: http://www.amap.no/arctic-climate-impact-assessment-acia Many Strong Voices Program develops research, assessment, networking facilitation, support to regions and communities, communication and outreach, and action on climate change mitigation: http://www.manystrongvoices.org/about.aspx?id=5159
IPCC – Working Group II (Impacts, Adaptation, and Vulnerability)	Assessment Reports, Special reports, methodology reports, technical papers and supporting material of the state of knowledge on Climate Change. https://www.ipcc.ch/report/ar5/wg2/
European Commission	EUNETMAR, a study on Arctic lay and traditional knowledge: (https://webgate.ec.europa.eu/maritimeforum/en/node/3569 The Northern Periphery and Arctic 2014–2020 Programme establish actions to protect, promote and develop cultural and natural heritage: http://www.interreg-npa.eu/ The Strategic Assessment of Development of the Arctic: Assessment Conducted for the European Union, recommends to give a voice to Arctic communities in policy developments that may affect them (chapter 9): http://www.arcticinfo.eu/en/

(2009,p.42) states, the expectations were not optimistic:

> "even in the cases where the imminent flooding or erosion threat is clear, the efforts of federal and state programs to provide assistance, thus far, have resulted in little progress toward relocation. Collaborating together, the federal government and the state government have an opportunity to address these threats in a thoughtful, reasonable, and environmentally sound manner. As time passes without significant progress being made on these village relocations, the potential for disaster increases, as does the ultimate cost of moving the villages out of harm's way."

The case of Alaska native villages shows the enormous complexity of climate-related displacements leading to further relocation processes and decision-making. In the absence of effective participatory channels previously established, the decisions become controversial. Meanwhile, increasing coastal storms and erosion, thawing permafrost, and other climate-related impacts, continue to threaten the future of these communities. Regarding the situations in which relocations occur (Petz, 2015), engagement and integration of traditional knowledge could be extremely useful in anticipation of environmental change and the effects of climate change.

3. Engagement potentials and integration of traditional knowledge into policy-making

Climate impacts and displacements have several implications for local native communities and their livelihoods; thus, there is a progressive and increasing recognition of the importance of traditional knowledge in international policy (Berkes et al. 2006; Abele, 2007; Turnhout et al. 2012). At the international level, the "Agenda of the Twenty First Century," adopted in 1992 by the participants of the World Summit in Rio de Janeiro, recognised the importance of traditional knowledge of indigenous populations (Assembly, 1992). More recently, the need to engage native communities in decision-making processes and the recognition of traditional knowledge was established in the Anchorage Declaration (2009) within the United Nations Framework Convention for Climate Change.

Traditional knowledge is an invaluable way of knowing and essential to the economic and cultural persistence of native peoples (Arrow, 1996; Purcell, 1998; Vinyeta and Lynn, 2013). It has been conceptualised as a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment (Berkes, 1993, Gadgil et al., 1993, Berkes et al., 1995).

Many fields of study and authors recognise traditional knowledge vital to the adaptation and resilience capacity of local peoples when facing new environmental conditions (Inglis, 1993; Berkes, 2004; Folke, 2004; Berkes and Turner, 2006; Ruiz-Mallén and Corbera, 2013; Pulsifer et al. 2014; Muir, 2015); its integration into policy-making has generated an intense public debate for several decades (Abele, 1997). Thornton and Scheer (2012) address the usefulness of local traditional knowledge to improve understanding of marine systems and foster adaptive management as they change. Regarding the Alaskan case study shown above, Alaskan natives have experienced accumulative effects of climate change. Erosion and flooding put communities at risk in their traditional homelands: changing ecosystems affect food security, the health of traditional plant and animal species used for food and traditional ways of life; changing snow, ocean, river, and lake ice conditions make travel more difficult and dangerous; and drier, hotter summers contribute to health problems due to smoke from increased occurrence and size of wildfires (Markon et al., 2012).

Arctic peoples have moved through the land, navigated the sea, and crossed the ice, using knowledge of routes passed down through generations, allowing them hunting and fishing in the relevant seasons (see http://paninuittrails.org/index.html). For instance, peoples living in

northern Greenland's Thule district, the northernmost inhabited area in the world, have traditionally moved through the territory for fishing and hunting. Mobility has been central to identity, but now fog and changing weather are affecting sledding patterns (Hastrup and Skrydstrup, 2013).

International law has recognised the essential nature of aboriginal consultation and participation and policy strategies supporting traditional knowledge. Specifically, indigenous representatives have suggested several proposals focused on the recognition of the relevance of traditional knowledge in developing strategies to address climate change and safeguarding the effective participation in formulating, implementing, and monitoring activities, mitigation, and adaptation relating to impacts of climate change, among others (Anchorage Declaration, 2009). The engagement of native peoples in governance processes is essential to ensure that they are not marginalised at the local level. The importance of recognising traditional knowledge as a relevant source of knowledge for adaptation has been increasingly reflected in programs and projects by the main international governance bodies working on Arctic and climate change policies (Table 2).

The UNESCO Conference on "Climate Change and Arctic Sustainable Development: Scientific, Social, Cultural, and Educational Challenges" (2009) recommended promoting traditional knowledge of indigenous peoples of the Arctic since these communities are capable of developing adaptation strategies responsive to environmental changes. In addition, the Arctic Council has promoted the use and integration of traditional and local knowledge into their projects and activities, published numerous recommendations for the integration of traditional and local knowledge, recognising the complementarity of science and traditional knowledge to generate new knowledge and inform decision making and policy development.

Although Arctic peoples representation has been recognised by the relevant policy institutions and organisations, the use of traditional knowledge as a valuable source of knowledge has not been universally accepted by relevant scientific bodies. The Intergovernmental Panel on Climate Change (IPCC) is generally recognised by the scientific community and policy-makers as one of the most authoritative policy-relevant bodies on climate change science. This institution has made important progresses on identifying and establishing a wide collection of mitigation and adaptation options to contrast climate change impacts. However, it has been noted that in general the level of adaptation has been inadequate for a reduction in vulnerability to future climate change (Mimura et al., 2015). According to several authors and researchers, the IPCC maintains a partial approach to native traditional peoples and knowledge; for instance, according to Huntington (2011), although the IPCC includes a discussion related to traditional knowledge in its sections on Africa and Polar regions, the consideration of this topic for other parts of the world is poor. Additionally, the methods for gathering data and information are still based on western scientific knowledge. In a similar way, Ford et al. (2012) state that the Working Group II of the IPCC recognises the importance of traditional knowledge in adaptation and resilience, but it does not integrate this knowledge into assessments processes. A preliminary analysis, carried out by Pachauri et al., (2014), of traditional knowledge and related issues in the 5th Assessment Report of the IPCC reveal important gaps and illustrate that, despite the considerable progress since the previous report, much more remains to be done. Ford et al. (2006) concluded that the coverage of native issues is general in scope and limited in length, there is little critical engagement with indigenous knowledge systems, and the historical and contextual complexities of indigenous experiences are largely overlooked.

Table 3 shows some of the most common IPCC adaptation options assigned to each step of the adaptation planning process in marine and coastal areas. The table shows how the IPCC adaptation options might be complemented or supported by other alternatives derived from the use of traditional knowledge. In the case of the first step, *vulnerability and risk assessment*, different approaches are presented in order to show diverse valid possibilities to integrate traditional knowledge into this step; in the successive stages (*actions/measures; implementation; monitoring*) concrete examples are provided.

According to Thornton and Scheer (2012), whereas traditional knowledge is recognised as an alternative source of environmental information, when gaps in scientific knowledge or data exist, it is most likely undervalued. Furthermore, discrepancies between scientific data and local observations have been identified, for instance, on indicators related to sea ice extent and sea ice thickness (Baztan et al., 2017). Nevertheless, collaborative initiatives shown in Table 3, such as the LEO, SAON and CLEO Networks; the development of integrated approaches, such as the IPCCA or the implementation of toolkits,[1] as well as, many others, are making strong contributions in gathering and sharing information about climate and drivers of environmental change among the local communities. This is important because the lack of information and data might lead to conflicts about land use and resources exploitation due to disregard of relevant local variables in planning and development of activities. Gofman and Smith, (2011) state that identifying and mapping areas of cultural significance is crucial for preventing possible future conflicts between coastal communities and marine-based industries, which are expected to increase activities in the Arctic. There are many examples around the world where traditional knowledge is key to maintain livelihoods. For example, in Indonesia, the Sasi community has been managing fishing activity for decades using their own ecological knowledge resulting in a stable regulation system of the different species in different coastal villages (Utomo, 2010). According to Roux et al., (2018) local observations using traditional knowledge are very useful sources to provide and collect information at coastal areas, to assess cumulative effects of multiple stressors (Mantyka-Pringle et al., 2017), or to serve as 'proxy data' measuring temperatures in remote areas (Alexander et al., 2011). Thus, the combination of observation technologies with local and traditional knowledge is not a speculative suggestion since new "observation systems" that include indigenous and local knowledge have been already implemented, for instance, using GPS technologies that capture real time observations of local users (Gearheard et al., 2011; Galginaitis, 2013; Kumpula et al., 2012). Traditional knowledge is not only about the information collected but also about the methods and ways of relating to what needs to be known. The relationships of Arctic communities with their environment determine what needs to be known and eventually who shall act on that knowledge.

4. Lessons learned, challenges and recommendations

Traditional knowledge is co-produced with the interaction of the communities with the ecological conditions in order to develop effective situated adaptation strategies. In other words, traditional knowledge cannot exist independently of the place and the communities that build it. It refers to the purposeful understanding of the local ecological system and has evolved over decades and generations due to systematic observations of complex issues, such as the dynamics of sea tides and currents, the use of local materials, weather and climatology, and local biodiversity and its behaviour, among others. Since this kind of knowledge is linked to complex local ecological conditions, each native community owns its specific traditional knowledge. Contrasting to this point, the IPCC adaptation approach entails an integration of different technological tools, such as modelling systems and GIS techniques, for instance, remote-sensing and global positioning systems. Technological observation systems and models are tools with an important value to monitoring and assessing the environmental changes occurring in the Arctic region, but the information and data gathered through these

[1] A toolkit provides methodological options and practical examples to support communities on the implementation of Local Assessments. See http://ipcca.info/toolkit-en-ipcca-methodological-toolkit.

Table 3
Different adaptation outputs established by scientific knowledge and other initiatives based on traditional knowledge.

Adaptation steps	IPCC examples of adaptation indicators and options (IPCC fifth Assessment Report 2014. Adaptation needs and options, p. 844))	Examples of the use of Traditional Knowledge	Initiatives / Institution / organisation	Region
Vulnerability and risk assessment	Distribution of marine species (IPCC data come, for example, from distribution models).	Use of local observer networks	SAON Network: Sustaining Arctic Observing Networks	Arctic region
			ELOKA: The Exchange for Local Observations and Knowledge of the Arctic (www.eloka-arctic.org/).	Arctic region
	Hazards mapping	Bio-cultural Assessments Approach	The Indigenous Peoples Climate Change Assessment (IPCCA) (www.ipcca.info)	Global
		Community-based approach	Climate Vulnerability and Capacity Analysis (CVCA) - CARE Climate https://careclimatechange.org/	Global
Actions / measures	Land use management and planning	Identify sites for settlements on high ground (Mercer et al., 2007)	Participatory three-dimensional 3D (https://www.weadapt.org/)	Global
	Sea walls and coastal protection structures	Use of local materials (Hiwasaki et al., 2014)	Many Strong Voices (http://www.manystrongvoices.org)	
Implementation	Fisheries co-management, for example: controlling overfishing	Identify problems and solutions (Robards et al., 2018; De Lara and Corral, 2017); determining the spatial distribution of species or fish behaviour (Raymond-Yakoubian et al., 2017; Roux et al., 2018); mapping areas of cultural significance (Gofman and Smith, 2011); identify changes in fishing areas (Raymond-Yakoubian et al., 2017).	Climate Witness Community Toolkit (WWF GLOBAL) wwf.panda.org/?162722/Climate-Witness-Community-Toolkit	South Pacific
Monitoring	Coastal erosion and/ or coastal ecosystem health (images, satellites, buoys, etc.)	Observing and documenting coastal pollution and/or ice thickness (Davies, 2007).	LEO Network: Local Environmental Observer Network https://www.leonetwork.org Alaska Native Tribal Health Consortium (ANTHC) https://anthc.org/ CLEO Network: Circumpolar Local Environmental Observer (Arctic Council, the Arctic Contaminants Action Program (ACAP) and its Expert Group the Indigenous Peoples' Contaminants Action Program (IPCAP)) https://oaarchive.arctic-council.org/handle/11374/1715	Arctic region

technologies have significant uncertainties and shortages (National Research Council, 2006). Marine resources planning and management is an emblematic case; while there is a lack of scientific information and data about species distribution and their biotic interactions (Bellard et al., 2012; Zarnetske et al., 2012) traditional knowledge holders have proven their capacity to provide information on aspects such as fish stock structure, variability and abundance, fish distribution and migrations, the behaviour of larval/post larval fish, or changes in habitats (Johannes and Neis, 2007; Christiansen et al., 2014; Baldwin et al., 2018).

Adequate traditional knowledge engagement into science and policy-making could benefit adaptation and mitigation strategies and policies to support Arctic communities with settling and coping with climate change driven adversities. Below, we summarise possible actions to ensure that traditional knowledge is marshalled into those processes:

- Foster collaborative engagement of traditional knowledge and science

Increasing indigenous representation at the international level and in forums is a historical advancement with regards to community engagement in decision-making processes, but it does not seem sufficient to integrate traditional knowledge into effective science activities and policy outcomes. In general, there is an increasing recognition of traditional knowledge by policy-makers and scientists, but it is necessary to encourage its uses in order to steer useful policies related to potential Arctic climate-induced displacements. The opportunity for an effective integration of traditional knowledge into the whole policy design cycle, from policy-shaping to policy-making and implementation, is an asset.

Policies might increase their effectiveness and their social value with adequate engagement strategies and a complete recognition of native peoples as active knowledge-holders, before displacements of vulnerable communities and relocations occur. Thus, it is desirable that in order to avoid a situation of knowledge monopoly on the establishment of climate policy advice (Tol, 2011). To this end, policy-makers should visit and learn from Arctic peoples on the Arctic peoples' terms. Relying on top-down, large-scale processes such as the IPCC and UNFCCC without understanding their mandates and the resulting limitations, or accepting information from a single source, and not recognising diversity within published science amounts to bad practice (Kelman, 2010; Kelman, 2017). What policy-makers often receive as scientific advice is a selection of scientific results, which constitute the basis for climate policy decisions (Vasileiadou et al., 2011). In order to breakdown this limited cycle, the development of more participatory and inclusive policy-making strategies opens the path to be closer to the reality where traditional knowledge develops and is used; nevertheless, participatory processes require primarily an open and honest recognition by scientists and by policy-makers of the diversity of knowledge systems, as well as establishing safe and honest sharing spaces (Hernández-González and Corral, 2017).

The main challenge would be to develop a novel framework that integrates and supports both traditional knowledge and scientific knowledge systems opening new channels for knowledge-based policy making. This means, the establishment of effective and closer collaborations on the ground with native communities accepting several difficulties, such as costs or language barriers, which could undermine opportunities for shared learning (Armitage et al., 2011).

- Recognise the value of traditional knowledge and change the approach towards a framework of co-creation of knowledge.

A recognition by the scientific community of traditional knowledge as a valid source of reliable data and information could enable cooperation among the scientific and the Arctic communities, leading to knowledge co-creation. Thus, it is necessary to enable the conditions in which actors co-learn in interaction with uncertainty and environmental change, or "learn to be adaptive" (Armitage et al., 2011) through knowledge co-creation processes.

As Armitage et al., (2011) define, adaptive capacity as the ability of an individual or a community to cope with, prepare for, and/or adapt to disturbance and uncertain social-ecological conditions. Environmental problems are complex because the routes of their causal chain are intricate interactions between biological, physical, and social systems (Lemos and Morehouse, 2005; Corral et al., 2017). As seen in the case of Alaska native villages, relocation processes are very complex; hence, these kinds of decisions should not be driven only by conventional science reports. Through knowing (1) the meaningful economic, cultural, institutional, legal, and social costs; (2) the different actors involved; and (3) the inherent social and economical uncertainties of climate-related displacements, a change of approach is possible, i.e. one that is connected to concrete in the ground situations.

The presence of representatives of indigenous peoples at international forums facilitate the expression of the interests, matters of concern and of care of each indigenous group, but does not guarantee the integration of traditional knowledge into policy-making; following Ferris (2013), it is not enough for indigenous groups to produce declarations and reports that are primarily read by other indigenous groups and human rights advocates.

Regarding the institutional context, the majority of Arctic-oriented institutions and organisations recognise the importance of traditional knowledge in science-based policy-making. For instance, the Arctic Council emphasises the need to foster relationships among governments, indigenous peoples, organisations, and other parties through partnerships and effective communication, and the need for traditional knowledge to be incorporated from the outset of a project or activity and used together with scientific results and analysis (Secretariat, 2017). Nevertheless, further work needs to be done, and the pledge for a more consensus-based and inclusive approach by the IPCC is growing in importance among the research community (UNESCO, 2009; Beck, 2011; Beck, 2012). As Silke Beck et al., (2014) uphold, "in contrast to the IPCC, the IPBES (*Intergovernmental Platform on Biodiversity and Ecosystem Services)* accords greater value to regional and local scales, this refers not only to the scale of assessments but also to the inclusion of local and indigenous knowledge". Along the same line, Alexander et al. (2011) emphasised that indigenous knowledge narratives are marginally included in IPCC or other global assessments of climate change. Other authors, such as Smith and Sharp (2012) provide evidence on this narrative when assessing the levels of inclusion of traditional knowledge by institutions such as the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, the Intergovernmental Panel on Climate Change's Fourth Assessment Report (AR4), and the Arctic Climate Impact Assessment (ACIA) concluding that there is no reference to this kind of knowledge in either the UNFCCC or the Kyoto Protocol, while the inclusion in the AR4 is marginal, being the ACIA the most inclusive document. Other authors state that indigenous issues, including their knowledge, have been underrepresented in the way of work and approach to climate change by the IPCC (Ford et al., 2016; Alexander et al., 2011) since this organisation maintains a knowledge monopoly (Tol, 2011).

- Avoid imprecise policies and vague recommendations

Developing specific actions, strategies and recommendations is desirable. As seen in Section 3, many recommendations made from international organisations and institutions working on Arctic's climate change and traditional knowledge are too general to accomplish any kind of concrete result or effective integration of traditional knowledge into policy-making. Well-meaning intentions and vague proposals lead to illusion of progress.

Traditional knowledge is a viable source for co-creation of knowledge. Therefore, the channels and paths to integrate it into policy-

making processes should be explored and concretised, just as the channels for conventional scientific knowledge are established. To this end, local peoples should be considered as great allies to analyse and monitor ecological dynamics of the region, such as detecting changes and impacts, as well as, giving assistance to identifying research priorities and policy agendas. According to Markon et al., 2012, local observers apply traditional knowledge to identify whether an occurrence is unusual or significant; in this sense, local observers provide invaluable surveillance for change. International Arctic institutions already have the capacity to provide resources to achieve the following objectives: to integrate traditional knowledge into risk assessment processes and projects; to carry out participatory environmental impact assessments at local level taking into consideration the knowledge of native peoples about ecological conditions and how these are changing; to implement projects related to resources availability assessments; to assess fish stocks, as well as, selection and identification of fishing areas; data gathering; establishing the best criteria to designated environmental protected areas, etc.

- Avoid over-protectionism and paternalism

In order to overcome these challenges it is necessary to change mind-sets, deconstruct myths and develop a critical view since there are many dominant attitudes towards climate change, potentially linked migration, and climate change related knowledge (Beck, 2012; Kelman, 2014). Many of those are based on myths which propagate despite lack of evidence; e.g. 'that millions of climate refugees will descend on us in hordes'; 'that polar bears and/or ice represent the Arctic' (Kelman, 2018); or 'that the IPCC represents the best of scientific knowledge' (Kelman et al., 2016). We need to continually evaluate, and critically reflect about the dominant attitudes, in order to cut through the rhetoric to the real evidence, to the scientifically published viewpoints (even if divergent from the mainstream), and to what the peoples know and seek, not what prominent climate change scientists claim on their behalf (Kelman, 2017).

Developing a critical view requires the avoidance of an over-protectionist vision of traditional knowledge. In this sense, culture and knowledge, by definition, are dynamic and must adjust to any changes around them (Mercer et al., 2009; Krüger et al., 2015). Thus, the continuation of an excessively protectionist vision will maintain non adaptive practices, lessening the opportunity to develop more appropriate strategies to the changing realities and, reducing the role of learning through change.

5. Final remarks

Community engagement actions should be directed to develop adaptation strategies and avoid the exposed potentially negative impacts so as to benefit from the potentially positive impacts while the situation is still manageable. This paper illustrates how climate-related displacements and subsequent relocation are extremely complex processes derived from multi-related causes. In complexity, the integration of different sources of knowledge in order to develop effective adaptation strategies is being increasingly relevant for international, regional, and local actors. However, traditional knowledge is not completely integrated by all scientific and policy spheres as an equally relevant source of knowledge. Indeed, climate change adaptation policies are often grounded in conventional scientific knowledge, but the perspectives, observations, and adaptation strategies from indigenous groups and communities, which have historically dealt with ecological changes, are not entirely integrated (if not mostly disregarded) into scientific assessments, reports, and conventional policy-making channels. The robust knowledge of Arctic native peoples and cultures is essential to creating consistent strategies and effective policies that reflect the historical and daily reality of life in the Arctic. In order to achieve this, a closer collaboration on the ground of all actors would be necessarily positive, since involving indigenous groups at international forums of discussion is not sufficient. Inherent to traditional knowledge are individual and collective relationships to the territory, different needs and concerns, which imply ways of knowing that correspond to particular expectations about what needs to be known and who should something about that knowledge. We suggest that normalised mainstream scientific assessments and measurements (incl. used methods) may not necessarily capture those needs and therefore be unfit for purpose. Like with traditional knowledge, scientific measurements and assessments equally determine what needs to be known and to a certain degree who is entitled to act on those outcomes.

Hence, we suggest that scientists, technical experts, and policy-makers establish and use closer cooperation channels with local native communities. These channels could be developed through, e.g. collaborative networks, observer networks, citizen science initiatives, and projects based on traditional knowledge, since these kinds of actions would allow on the one hand, a direct connection and collaboration between Arctic peoples and scientific organisations and actors; and on the other hand, it would allow the elaboration of more concrete strategies and policies.

Having identified the sources of environmental impacts at the local level, which potentially cause displacements, the institutions should facilitate and support the establishment and development of local observer networks. These local observers can use their traditional knowledge by monitoring environmental changes through a systematic documentation of their observations in close collaboration with scientific organisations, such as the IPCC and other actors. Since representation of indigenous groups in forums and institutions does not necessarily imply the integration of traditional knowledge, it would be beneficial for indigenous representatives to connect to the initiatives and results of these local observer networks to inform their international activity and help in the formulation of regional, national, and international policies.

Without these types of effort, climate displacements and subsequent relocations could increase in the future, leading to significant effects such as the loss of knowledge and practices, which entail a significant value for human environmental adaptation.

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